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**Kamen et al.**(10) **Pub. No.: US 2019/0134298 A1**(43) **Pub. Date: May 9, 2019**(54) **SYSTEM, METHOD, AND APPARATUS FOR ESTIMATING LIQUID DELIVERY****Publication Classification**(71) Applicant: **DEKA Products Limited Partnership**,  
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**Colin H. Murphy**, Cambridge, MA (US)(21) Appl. No.: **16/241,239**(22) Filed: **Jan. 7, 2019**(51) **Int. Cl.****A61M 5/142** (2006.01)**G01F 23/296** (2006.01)**A61M 5/168** (2006.01)**G06Q 50/22** (2006.01)**A61M 5/145** (2006.01)(52) **U.S. Cl.**CPC ..... **A61M 5/142** (2013.01); **A61M 2205/3379** (2013.01); **A61M 5/1684** (2013.01); **G06Q 50/22** (2013.01); **A61M 5/1452** (2013.01); **A61M 2205/3592** (2013.01); **A61M 2205/581** (2013.01); **A61M 2205/582** (2013.01); **A61M 2205/6054** (2013.01); **A61M 2205/6072** (2013.01); **A61M 2205/3375** (2013.01); **A61M 2205/3306** (2013.01); **A61M 2205/18** (2013.01); **A61M 2205/50** (2013.01); **G01F 23/296** (2013.01)**Related U.S. Application Data**

(63) Continuation of application No. 15/467,196, filed on Mar. 23, 2017, now Pat. No. 10,220,135, which is a continuation of application No. 13/723,251, filed on Dec. 21, 2012, now Pat. No. 9,636,455, which is a continuation-in-part of application No. 13/333,574, filed on Dec. 21, 2011, which is a continuation-in-part of application No. PCT/US11/66588, filed on Dec. 21, 2011.

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(57)

**ABSTRACT**

A pump includes a reservoir, a port, and a plunger. The reservoir delivers a liquid by discharging the liquid through the port coupled to the reservoir. A piston of the plunger defines a liquid side of the reservoir and a non-liquid side of the reservoir whereby movement of the plunger towards the liquid side of the reservoir discharges liquid through the port. The pump also includes a reference-volume assembly and/or a linear position sensor. The reference-volume assembly is coupled to the reservoir at an opposite end of the reservoir relative to the port and includes a reference-volume chamber in acoustic communication with the non-liquid side of the reservoir, a speaker disposed within the reference-volume chamber, and a reference microphone disposed within the reference-volume chamber. The pump estimate the amount of liquid discharged from the reservoir.

